WO 2005/073426 PCT/CA2005/000097

What is Claimed

1. A method for enhancing the surface hardness and smoothness of cobaltchromium alloys through exposure in a reaction vessel to a mixture of reaction gases at a partial pressure (less than atmospheric) within a temperature range of 250°C to 1000°C for process time sufficient to create a substantial compound layer.

- 2. The method of claim 1 wherein the reaction vessel utilizes a pulse plasma glow discharge as a media for the reaction.
- 3. The method of claim 1 wherein the total pressure of reaction gases is 0.5 to 100 mbars.
- 4. The method of claim 1 where the temperature is 400°C to 600°C
- 5. The method of claim 1 wherein the reaction gases are Ar, N2, H2.
- 6. The method of claim 3 wherein the reaction gases are Ar, N2, H2.
- 7. The method of claim 1 wherein the reaction gases are Ar, N2, H2, CH4.
- 8. The method of claim 3 wherein the reaction gases are Ar, N2, H2, CH4.
- 9. The method of claim 1 wherein the reaction time is 6-42 hours
- 10. The method of claim 1 wherein the reaction the reaction time is approximately 24 hours.
- 11. The method of claim 1 where the pulse pause ratio is 1:0 to 1:50.
- 12. The method of claim 3 where the pulse pause ration is 5:1 to 1:20.
- 13. The method in claim 1 in which the identified hardened surface contains a compound layer of Cr-N of 1 to 20 microns thickness.
- 14. The method in claim 1 in which the identified hardened surface contains a compound layer of Cr-N of 3 to 15 microns thickness.

WO 2005/073426 PCT/CA2005/000097

15. A method for enhancing the surface hardness and smoothness of a cobalt chromium material and with surface hardness and smoothness improved through exposure in a reaction vessel to a mixture of reaction gases (Ar, N₂, H₂, CH₄) for process time sufficient to create a compound layer substantially comprised of chromium nitrides.

- 16. The method of claim 15 wherein the reaction gases are Ar, N_2 , H_2 .
- 17. The method of claim 15 wherein the reaction gases are Ar, N_2 , H_2 , CH_4 .
- 18. The method of claim 15 wherein the said material is ASTM F-75 and ASTM F-75 Modified alloy
- 19. The method of claim 15 wherein the process temperature is held between 400°C to 600°C.
- 20. The method of claim 15 wherein the process partial pressure is held at less than atmospheric.
- 21. The method of claim 15 wherein the process partial pressure is held at approximately 1-10 mbars.
- 22. The method of claim 15 wherein the said cobalt chromium alloy is ASTM F-799, F75, and F75 modified.
- 23. A method for enhancing the surface hardness and smoothness of a cobalt chromium molybdenum base material and with surface hardness and smoothness improved through exposure in a reaction vessel incorporating pulse plasma of reaction gases varies in on-to-off process levels.
- 24. The method of 15 and 24 where in the pulse plasma on-to-off ratio is 2:1 to 1:10.
- 25. The method of 1, 3, and 15 through exposure in a reaction vessel incorporating convection preheating.
- 26. The method of 1, 3, and 15 through exposure in a reaction vessel incorporating single and multi zone cooling

WO 2005/073426 PCT/CA2005/000097

27. The method of 1, 3, and 15 through exposure in a reaction vessel incorporating a central anode.

- 28. The method of 1, 3, and 15 through in a reaction vessel wherein the parts are masked to prevent nitriding in unwanted areas.
- 29. The method of 1, 3, and 15 through exposure in a reaction vessel incorporating helium as a replacement carrier gas for the hydrogen.
- 30. The method of 1, 3, and 15 through exposure in a reaction vessel incorporating thermocouple temperature measurement of the parts.
- 31. The method of 1, 3, and 15 through exposure in a reaction vessel incorporating a sputter step to increase the surface reactivity of the workpiece.
- 32. The method of any one of claims 15 to 31 wherein the creation of a substantial nitrogen diffusion layer is avoided.
- 33. The method of claim 1 wherein the reaction vessel utilizes a plasma glow discharge as a media for the reaction.
- 34. The method of claim 1 wherein the reaction gas is nitrogen.
- 35. The method of claim 1 wherein the reaction gases are nitrogen and a carrier gas with optionally argon and optionally a carbon precursor.